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DESIGN, PROCESSING AND CHARACTERIZATION OF SHAPE MEMORY POLYMER COMPOSITES AND BLENDS

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Shape-memory polymeric materials have emerged as a set of stimuli responsive materials which have ability to undergo a shape change and revert back to their memorized permanent shape upon exposure to external stimuli. Since the discovery of shape-memory (SM) effect in polymers, SMPs have attracted significant attention and have been developed and demonstrated for advanced applications. The properties of SMPs can be further enhanced by either creating shape-memory composites (SMCs) through incorporation of micro/nano sized fillers or blending with another suitable polymer entity.

The experimental research work was aimed at developing new thermally responsive shape-memory polymer composites/blends and tailoring their properties for biomedical applications. At first the novel thermally responsive SMCs were fabricated by compacting mats of electrospun poly(vinyl alcohol) (PVA) fibers and sheets of an thermoplastic polyether-block-amide elastomer (PEBA). The introduction of electrospun PVA fibers led to increase in the mechanical properties compared to the neat PEBA, while the T_g of PVA (85 °C) was utilized to fix a temporary and recover the permanent shape. Secondly commercially available thermoplastic polyurethanes (PUs) consisting of crystallizable soft/switching segments that display shape-memory effect were explored. The research undertaken demonstrated that the thermomechanical properties of such SMPUs can be modified by formulating nanocomposites using bio-based cellulose nanocrystals (CNCs) as filler and/or influencing the crystallization of the soft segments via the addition of a nucleating agent employing an industrially relevant melt-mixing process. For the shape-memory applications in the biomedical field, it is important that the fixation and recovery temperatures of such SMPUs can be minutely controlled. The design approach of blending a crystalline polymer of the same chemical nature as that of soft/switching segments in the SMPU was studied. The results showed that the blending approach shifted the crystallization temperature of the switching phase from below to above ambient temperature, and excellent shape fixity (~ 98%) could be achieved at 37 °C.

In summary, this research framework successfully reports fundamental understanding of composition-processing-property relation of novel shape-memory materials and explores the possibilities of tailoring their properties that may be useful for the biomedical applications.

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